I. BASIS AND SCOPE

On October 19, 2007, a leak occurred in the essential service water system at Byron Nuclear Station (Byron) that resulted in the shutdown of both reactors **(FOOTNOTE 1)**. The leak in the essential service water system was due to corrosion of piping located in the valve vault.

The essential service water system is a risk significant system, and corrosion of essential service water piping had been an ongoing problem at Byron since at least 1990. For these reasons, OIG initiated an inquiry into the NRC's awareness of corrosion in the essential service water system at Byron and the adequacy of actions taken by NRC since 2000 to address ongoing corrosion problems at Byron.

II. BACKGROUND

<u>Essential Service Water System at Byron</u>

Byron is located in northern Illinois near the city of Byron and the Rock River **(FOOTNOTE 2)**. There are two pressurized water reactor (PWR) plants located on the site, both very similar in design. Each reactor produces approximately 3600 megawatts of thermal energy and generates approximately 1200 megawatts of electrical power.

The Byron essential service water system (SX)**(FOOTNOTE 3)** provides cooling water for multiple safety related systems and components. Figure 1 provides a simplified depiction of the Byron SX with arrows indicating direction of water flow: blue lines

represent piping containing “cool water” and red lines represent piping containing “heated water.” While large section of the SX piping are above ground, a portion of the piping that transports water to and from the SX cooling tower **(FOOTNOTE 4)** is underground. The water becomes heated as it cools the safety related equipment. The heated water then flows to the SX cooling tower where it is cooled. The cooled water then flows back to continue cooling the safety related equipment. In this manner the SX forms a “closed loop,” whereby the same water **(FOOTNOTE 5)** continuously flows through the system in repetitive cycles of heating and cooling. Because safety related equipment needs continuous cooling for normal operations and emergencies from water provided by the SX, the SX is one of Byron’s most risk significant systems.

The SX cooling tower consists of eight cells each containing a fan and spray nozzles. The hot water flows in to the upper portion of the cooling tower cell and is sprayed through nozzles forming a mist inside the cell. Air moving upwards in the cell cools the heated water mist, and the cooled water mist floats downward in the tower cell and collects a large basin below all the cells. The cooled water is pumped from the basin back to the portion of the SX that cools the safety related equipment, and the cooling cycle starts over.

(INSERT FIGURE 1)

Near the cooling tower structure, underground SX pipes transport the hot water to each cooling tower cell. These pipes are 24 inches in diameter and emerge from the ground through a concrete floor inside a concrete valve vault (vault). After penetrating the floor, the pipe connects to a bolted flange. The pipe connected to the other end of the bolted

flange rises vertically and exits the vault. Each pipe section above the flange includes a single valve. This pipe directs hot water onward to the spray nozzles in the cooling tower. The vertical section of piping inside the vault, above and below the flange, is referred to as a pipe riser.

There are eight nearly identical vaults corresponding to the eight cooling tower cells. These vaults are constructed of concrete with removable steel hatch plates that allow personnel entry into the vaults. The hatch plates require a crane for removal. The vaults provide physical protection for its internal components against the impact of high velocity debris associated with a tornado. Figure 2 is two photographs of the lower section of a pipe riser inside a vault; one photograph provides close-up detail of the rusted condition of the lower segment of a pipe riser. Note that the piping above the bolted flange is not rusted. The reason for corrosion below the flange and the lack of corrosion above the flange is discussed in the following section of this report.

(INSERT FIGURE 2)

<u>Problems with Corrosion of SX Pipe Risers</u>

Byron has a history of corrosion of SX piping in the cooling tower vaults. Excessive corrosion on this piping had been identified by EXELON, the Byron licensee, as far back as 1990. In 1990, the licensee attributed excessive corrosion of SX piping in the vaults to a failure of pipe coatings. The condition was described by EXELON as extensive with loose scaly rust which originated on the outside surface of the piping. Corrosion

beginning on the outer surface of a pipe and migrating to the inner surface is termed "outside-in" corrosion.

In 1994, EXELON issued a modification to replace SX carbon steel piping in the vaults with stainless steel piping because of the enhanced corrosion resistance of stainless steel. In 1997 and 1998, the modification resulted in the replacement of the SX piping above the bolted flange; however, the short section of pipe riser coming through the concrete floor and terminating below the bolted flange was not replaced. The lower section of the pipe was originally within the scope of the modification but was removed from the scope and replacement was never rescheduled.

On October 19, 2007, a pipe riser in one of the vaults began to leak below the bolted flange. The leak occurred when licensee staff began brushing the pipe to remove rust from the surface of the pipe to prepare it for ultrasonic (UT) examination to measure pipe wall thickness. UT is a common method of measuring pipe wall thickness using the transmission of sound waves through the pipe wall.

III. DETAILS

A. NRC Oversight of Corrosion of Byron Essential Service Water Piping

OIG interviewed EXELON staff regarding the monitoring of the condition of the pipes in the eight vaults at Byron. According to EXELON staff, the interior of the vaults is only accessible by use of a crane which is needed to lift the steel vault hatch.

EXELON provided OIG with historic information that reflected two separate preventative maintenance activities that required licensee personnel to open the vault hatches. The two activities were a visual inspection and a valve actuator inspection. From this information OIG determined that at least one vault at Byron was open and accessible a total of 39 days between 2000 and 2006. This number represents an average of approximately 5 days per year **(FOOTNOTE 6)** when at least one vault at Byron was open.

OIG reviewed NRC inspection reports conducted at Byron from 2000 to 2006. Two inspection reports **(FOOTNOTE 7)** were identified that refer to walk downs of the SX. Beyond these two reports, no other NRC inspection report for Byron described resident inspector or other NRC inspector walk downs of SX piping. In addition, none of the inspection reports contained any observations about the SX vaults, and none of the inspection reports during this 7 year period identified corrosion in the SX vaults.

NRC Integrated Inspection Report, dated January 29, 2003, described NRC inspection activities at Byron from October 1 through December 28, 2002. According to the inspection report, the resident inspectors conducted a complete system alignment walk down of the SX. The walk down included an electrical and mechanical walk down of the system to verify proper alignment, component accessibility, availability, and current condition. The inspection report contained no findings as a result of this walk down, no specific discussion of components in the SX cooling tower vaults, and no discussion of corrosion in the SX cooling tower vault.

NRC Biennial Safety System Design and Performance Baseline Inspection (SSDI) **(FOOTNOTE 8)** Inspection Report, dated May 20, 2005, described inspection activities

at Byron by an NRC inspection team from January 24 through February 11, 2005. The SSDI focused on two safety systems including the SX. According to the inspection report, detailed walk downs were conducted with a focus that included configuration of piping components and their susceptibility to environmental concerns. The walk downs did not result in any findings associated with SX corrosion, and the report contained no discussion of components in the SX cooling tower vaults and no discussion of corrosion of components in the SX cooling tower vaults.

OIG contacted six NRC employees who had been assigned as senior resident inspectors at Byron from 2000 to 2007. OIG asked each former senior resident inspector about their observations of corrosion in the SX vaults at Byron. Five of the former senior resident inspectors told OIG they did not recall ever looking inside the vaults. One former senior resident inspector recalled looking inside the vault. This inspector told OIG that he was a fill in for 2 to 3 months in 2000, and during that time he inspected the SX vaults two or three times. He told OIG he could recall some, but not any significant, pipe corrosion.

The remaining five former senior resident inspectors related to OIG that the primary reason for not inspecting the vaults was the vaults were not frequently accessed by the licensee. One former senior resident inspector stated he was aware of the need for reviewing infrequently accessed areas, and he acknowledged that the SX was a risk significant system for Byron. However, he could not cite a specific reason why he did not inspect any vaults. He noted that the NRC did not have a rigorous process for identifying risk significant equipment located in infrequently accessed areas or establishing a frequency for reviewing each of these areas. Another former senior resident inspector told OIG that he completed a short assignment as a fill in senior

resident inspector at Byron, and he had a number of other issues that he focused on. The remaining three former senior resident inspectors could not provide a specific reason for not inspecting the vaults except possibly a lack of awareness of ongoing licensee inspections. However, one of the former senior resident inspectors noted that any licensee work inside the vaults required a crane which should have increased the visibility of licensee entries into the vaults for the NRC resident inspectors.

B. NRC Oversight of Operability of Byron Essential Service Water System

NRC Regulatory Guidance to Licensees

There is NRC regulatory guidance that establishes expectations for licensees to evaluate operability after discovery of a degraded condition. Regulatory guidance in this area was promulgated in 1991 as an attachment to Generic Letter 91-18 **(FOOTNOTE 9)**. The regulatory guidance was revised in 1997 through issuance of Generic Letter 91-18, Rev. 1. The version of this regulatory guidance in place at the time of the Byron leak was issued in September 2005 as NRC Technical Guidance (Part 9900) **(FOOTNOTE 10)** which was attached to Regulatory Issue Summary (RIS) 2005-20. The attachment contained revised guidance for licensees concerning operability and degraded and non-conforming conditions. Generic Letters and Regulatory Issue Summaries are NRC communications to licensees; none of these communications required any specific action by a licensee.

Paraphrasing a relevant section of NRC Technical Guidance (Part 9900) **(FOOTNOTE 11)** promulgated in 2005, equipment is operable when it is capable of performing its

safety function. The guidance also specifies that determinations of operability be based on a licensee's reasonable expectations given available information about the current condition of a piece of equipment. The guidance adds that operability is an ongoing process and should be evaluated by the licensee without delay when equipment is discovered in a degraded condition. Significantly corroded piping in a safety system is an example of a condition requiring determination of the operability of the equipment and affected system.

NRC Technical Guidance (Part 9900) on operability refers to "immediate determinations" of operability and "prompt determinations" of operability. According to this guidance, after confirming the circumstances associated with a degraded condition the licensee should complete an "immediate determination" of structure, system or component (SSC) operability. The determination should be made without delay and in a controlled manner using the best available information. A "prompt determination" of SSC operability is a follow-up to an immediate determination of SSC operability. A "prompt determination" is warranted when additional information, such as supporting analysis, is needed to confirm the immediate determination.

Operability Evaluations Conducted of Byron SX Piping in 2007

OIG determined that the EXELON procedure for operability determinations in use at Byron provided definitions for "operability determinations" and "operability evaluations". An operability determination was a decision of a senior reactor operator concerning whether a piece of equipment was operable and, depending on the complexity of the issue, not all operability determinations were documented. An operability evaluation was a documented, detailed, rigorous evaluation of the impact of a degraded condition on a

piece of equipment. Operability evaluations were normally performed by engineering and may be used to support an operability decision. OIG was told by EXELON that the term “operability evaluation” and its associated definition had been used for many years by EXELON. EXELON acknowledged that this term was not an industry standard term; although, they were aware that other utilities used the term. EXELON provided OIG with records indicating that five operability evaluations were performed in 2006 and nine operability evaluations were performed in 2007 at Byron.

The original Byron design value for the pipe riser wall thickness in the eight vaults was 0.375 inch. As of June 2007, a minimum acceptable wall thickness for operability was 0.153 inch. One minimum acceptable wall thickness is applicable to all of the pipe risers. On June 14, 2007, EXELON completed pipe wall thickness measurements for the pipe riser in the “E” vault **(FOOTNOTE 12)**. Two measurements were taken and wall thickness values of 0.122 and 0.124 inch were reported. The licensee completed a detailed evaluation of operability on July 11, 2007, and lowered the minimum allowable wall thickness to 0.121 inch **(FOOTNOTE 13)**.

On October 10, 2007, the licensee completed pipe wall thickness measurements of the pipe riser in the “H” vault. Measurements were taken of riser pipe wall thickness measured at three locations around the perimeter. The measured wall thicknesses were 0.085 inch, 0.154 inch, and 0.150 inch. The licensee completed a detailed evaluation of operability on October 12, 2007, for the “H” riser and established a new minimum acceptable wall thickness of 0.06 inch.

On October 17, 2007, the licensee completed pipe wall thickness measurements of the pipe riser in the “B” vault. Measurements were taken of riser pipe wall thickness at 10

locations around the perimeter. The measured wall thickness was below 0.1 inch at each of these locations. The lowest reading recorded was 0.047 inch. On October 17, 2007, the licensee completed a detailed evaluation of operability for the "B" riser and lowered the minimum acceptable wall thickness to 0.03 inch. On October 19, 2007, the riser in the "C" vault began to leak below the isolation valve while licensee personnel were preparing the pipe riser for a measurement of wall thickness.

NRC Resident Inspector Oversight of SX Piping Operability Evaluations

OIG interviewed the NRC senior resident inspector and the resident inspector assigned to Byron when the UT measurements and operability evaluations were being conducted. These NRC inspectors told OIG that in 2007 they were aware that EXELON had conducted a number of UT examinations of pipe risers in the SX vaults and had reduced the allowable pipe riser wall thickness as a result of these examinations. The NRC inspectors told OIG that they did not review any of the SX operability evaluations conducted by the licensee between June and October 2007 that supported the reductions in allowable pipe riser wall thickness. The NRC inspectors explained that these evaluations were not included in the sample of licensee operability evaluations they selected to review in 2007.

The senior resident inspector provided OIG a list of 20 operability evaluations that the NRC resident inspectors reviewed in 2006 and 21 operability evaluations that the NRC resident inspectors reviewed in 2007. The senior resident inspector told OIG that the number of operability evaluations reviewed was based on the sampling requirements contained in NRC Inspection Procedure (IP) 71111.15 "Operability Evaluations". The

senior resident inspector added that the evaluations were selected based on his judgment about the safety significance of each issue. The senior resident inspector stated that 21 evaluations were selected for review in 2007 to meet the IP 71111.15 requirement that NRC resident inspectors review between 19 and 25 licensee operability evaluations a year for a two unit site like Byron.

The Byron senior resident inspector told OIG that the reason for the apparent discrepancy between the number of operability evaluations EXELON recorded as being conducted in 2006 and 2007 (five and nine, respectively) compared to the number of evaluations reviewed by the NRC was the licensee's definition of "operability evaluation". He explained that EXELON had two types of operability decisions. The first type of operability decision occurs when a licensed reactor operator **(FOOTNOTE 14)** makes an "operability determination" without the need for a detailed analysis. The second type of operability decision occurs when a licensed reactor operator makes an operability decision that is based on a detailed, documented analysis of operability. According to the senior resident inspector, EXELON procedures defined this detailed analysis as an "operability evaluation".

The senior resident inspector told OIG that although IP 71111.15 referred to "operability evaluations", it was his opinion the procedure meant "operability decisions" and, again in his opinion, inspectors should sample from all operability decisions based on safety significance. He acknowledged that EXELON did use the term "operability evaluations", but he did not believe this was a standard industry term with a specific definition. He estimated that at Byron there were several thousand operability decisions per year and only a very small number of decisions required a detailed "operability evaluation". The basis for his numbers, he explained, was the fact that Byron had several thousand

problem reports every year and a large number of these required some form of operability decision.

OIG reviewed IP 71111.15 **(FOOTNOTE 15)** and found that it provided direction to NRC inspectors for selecting and reviewing “operability evaluations” on risk significant equipment. NRC resident inspectors were supposed to review the evaluations for technical sufficiency and for sufficient justification for a determination of operability. The NRC inspection procedure directed resident inspectors to review 19 to 25 “operability evaluations” of degraded conditions that affect mitigating systems and barrier integrity cornerstones in a 1 year period for a two unit plant.

OIG’s review of IP 71111.15 and Technical Guidance (Part 9900) disclosed that neither document provided guidance regarding whether resident inspectors should draw their review samples from detailed operability evaluations, simple operability determinations, or both. OIG also determined that neither document discussed the need to review operability decisions when licensees used operability evaluations to repeatedly reduce the margin of safety on a piece of equipment such as occurred at Byron.

OIG learned that following the shutdown of both reactors at Byron, NRC inspectors on a Special Inspection Team reviewed the EXELON operability evaluations completed between June and October 2007 that justified the reductions in pipe wall thickness. In describing the results of this review, the NRC inspectors stated that the licensee engineering staff made substantive errors in the calculations that supported operability evaluations for the degraded SX pipe risers. NRC inspectors told OIG that the operability evaluations included fundamental errors.

Expectations of NRC Management

A senior official in the NRC Office of Nuclear Reactor Regulation (NRR) responsible for the development of NRC inspection procedures and guidance told OIG that there was no guidance for NRC inspectors to sample a certain number of simple operability determinations or to sample a certain number of detailed operability evaluations. The only guidance was IP 71111.15 which did not distinguish between simple or complex operability analyses. This same official told OIG that there was no NRC inspection guidance for inspectors to assess operability evaluations when licensees repetitively reduced the margin of safety for a piece of equipment.

The Director and Deputy Director of NRR told OIG that they would expect the NRC sampling process for resident inspector reviews of licensee operability decisions to establish a requirement that both detailed operability evaluations and less detailed operability evaluations be included in the review sample. They both expressed the opinion that there were important reasons for reviewing both types of evaluations including understanding what plant conditions were receiving a detailed review and what plant conditions were not receiving a detailed review by a licensee. The Director and Deputy Director agreed that sampling decisions should be based on the resident inspector's assessment of the safety significance of an issue.

The Director and Deputy Director of NRR also commented to OIG that while NRC inspection guidance should clearly establish sampling requirements for both types of operability decision, it did not matter what terminology was used by licensees to identify kinds of operability evaluations as long as the evaluations were consistent with NRC

guidance and understood by the inspectors. Both the Director and Deputy Director stated that the inspection guidance should provide direction to resident inspectors to address situations when licensees use operability evaluations to successively reduce the margin of safety, as occurred at Byron.

C. NRC Application of Foreign Operating Experience for Essential Service Water Corrosion (2004):

On August 25, 2004, a circumferential break in the essential service water system at the Vandellos **(FOOTNOTE 16)** nuclear plant resulted in a loss of one of the two trains of the essential service water system. The World Association of Nuclear Operations (WANO) **(FOOTNOTE 17)** identified the location of the failure as one of the contributing factors to this event. The failure location was not subject to routine inspection because it was located in an infrequently accessed area.

In 2006 the International Atomic Energy Agency (IAEA) published a public report **(FOOTNOTE 18)** describing the essential service water system pipe rupture at the Vandellos nuclear plant. The Vandellos event was one of only four material degradation events reported by IAEA in this document. The other events were a secondary pipe rupture event at the Mihama nuclear plant in Japan; guillotine feed water pipe breaks at the Loviisa nuclear plant in Finland; and the head corrosion event at the Davis Besse nuclear plant in the United States (US). According to the report, Vandellos experienced a circumferential break on manhole piping that was part of the essential service water system. The failure resulted from outside-in corrosion, indicating the corrosion started in the outside surface of the piping.

In October 2006, WANO published a Significant Event Report (SER) describing the Vandellos event. WANO SERs are written to facilitate the sharing of knowledge gained by operating experience. The Institute of Nuclear Power Operations (INPO) promulgated the WANO report in the US and provided a copy to the NRC. According to the WANO report, the neck on an inspection hatch at Vandellos ruptured circumferentially, thereby rendering the affected train of essential service water system inoperable.

According to the WANO report, the inspection hatch was located inside a pit which was covered with concrete slabs. According to WANO, the environmental conditions in the pit were generally unknown and inspections were conducted infrequently. The report added that Vandellos was an example of a nuclear station that had not implemented adequate methods for monitoring inaccessible piping. The report stated that while pit inspections between 1989 and 2000 identified external corrosion in these locations, few or no corrective actions were taken. The WANO report also identified inadequate design, installation, configuration control, organizational, management weaknesses and ineffective operational decision making as causes for the Vandellos event.

The WANO report provided five actions to help prevent design, installation and configuration control errors; five actions to help reduce surveillance and maintenance and program weaknesses; three actions to address organizational and management weaknesses; and one action to address operational decision making weaknesses.

Among these 14 actions, were the following 3 actions; (1) ensure that analytical and prediction tools consider the long-term environmental conditions for buried or inaccessible piping; (2) review environmental conditions of buried or inaccessible

essential service water (ESW) **(FOOTNOTE 19)** piping to determine if design assumptions remain valid; and (3) consider adjusting frequency and content of ESW piping surveillances and inspections especially for buried or inaccessible piping. Consequently, 3 of the 14 recommended actions for Vandellos addressed issues associated with infrequently accessed essential service water piping locations.

In a speech in May 2007 on "Improvements in NRC's Improved Use of Operating Experience," NRC Commissioner Peter Lyons **(FOOTNOTE 20)** stated that the NRC was evaluating the Vandellos event based on information provided by the international community. According to Commissioner Lyons, this information was being evaluated for applicability to US nuclear power plants and for further distribution to appropriate NRC staff.

D. NRC Staff Handling of Vandellos Operating Experience Information

NRC has an internal process by which the agency reviews domestic and foreign plant operating experience in an effort to prevent similar undesirable events at nuclear power plants in the US. As part of this process, NRC technical staff review foreign operating experience to determine applicability to US plants and to determine whether additional action may be necessary to prevent similar events at US plants. As part of the NRC process, the NRC Generic Communications Branch requests that cognizant NRC Branches review operating experiences and provide written feedback to the Generic Communications Branch. The Generic Communications Branch reviews the input and develops follow-up recommendations as appropriate.

In follow-up to the Vandellos event, the Generic Communications Branch prepared an internal memo **(FOOTNOTE 21)** that stated it was possible that essential service water piping systems at US nuclear power plants could be located in areas that were not readily accessible for inspection. The memorandum added that essential service water piping may be located in vault areas subject to periodic flooding and may closely mimic conditions at Vandellos. Therefore, degradation similar to that at Vandellos at US Plants could not be readily dismissed. The recommendations in this memorandum were to (1) issue internal operating experience communication to appropriate NRC technical staff; (2) issue an NRC Information Notice; (3) give an operating experience briefing; and (4) consider recommending changes to the NRC's inspection program.

OIG learned that NRC staff issued internal operating experience information about the Vandellos event on June 6, 2005, in reply to the recommendation to issue internal operating experience to NRC staff **(FOOTNOTE 22).** However, NRC resident inspectors at Byron told OIG that they did not recall receiving any operating experience information involving corrosion of the essential service water piping in infrequently accessed areas. These NRC resident inspectors also said no one from NRC headquarters contacted them regarding the potential applicability of the Vandellos event to Byron.

In response to the second recommendation to issue an Information Notice, NRC included some information regarding the Vandellos event in NRC Information Notice 2007-06 **(FOOTNOTE 23)** issued on February 9, 2007. The Information Notice discussed events at three plants that could have led to potential common cause failures of essential service water systems. Regarding the Vandellos event, the NRC

Information Notice stated that the event was caused by a failure to protect the piping and a failure to adequately track and take corrective actions for known degraded conditions.

NRC Information Notice 2007-06 did not address any of the problems identified by WANO associated with infrequently accessed areas that resulted in the Vandellos event. The Information Notice contained a statement that US plant essential service water systems may contain buried or not readily accessible piping, but the Information Notice offered no explanation as to the implications of this statement. NRC resident inspectors at Byron told OIG that they were not aware of any NRC generic communications related to the Vandellos event prior to the Byron service water leak. Additionally, EXELON staff at Byron told OIG they were not aware of any NRC generic communications about the Vandellos event.

In response to the third recommendation that an operating experience briefing be conducted, OIG determined that an operating experience briefing was conducted in NRC headquarters in April 2006. The NRC staff member responsible for the briefing told OIG the purpose of the briefing was to inform NRC staff of what occurred at Vandellos as well as to discuss events at other plants. The briefing was given to the NRR leadership team as part of the NRR bi-monthly operating experience program. The staff member also stated that regional staff normally reviewed the presentation slides and listened to the briefing via telephone. However, OIG located no documentation indicating that regional staff listened to this presentation.

In response to the fourth recommendation to consider revising the NRC inspection program, OIG learned that NRC inspection procedures were not revised to reflect lessons learned from the Vandellos event. NRC staff told OIG that they could not find

any documentation following up on the recommendation that NRC consider revising inspection guidance in response to the Vandellos event.

IV. FINDINGS

- This OIG inquiry disclosed that the NRC provided little meaningful regulatory oversight of corrosion of piping in the Byron essential service water system, one of Byron's most risk significant systems. The essential service water system at Byron had a history, dating back to 1990, of extensive corrosion of piping in the cooling tower valve vaults. Consequently, during 1997 and 1998, EXELON, the Byron licensee, replaced the carbon steel piping in the cooling tower area with stainless steel. In the eight valve vaults, the piping above the flange was replaced; however, the section of pipe coming through the concrete floor and terminating beneath the flange was not replaced. In the ensuing years, corrosion of this lower section of piping remained an issue. By June 2007, the original Byron design value for acceptable minimum wall thickness for piping in the eight valve vaults of 0.375 inch had been reduced to 0.153 inch. However, from 2000 to 2007, the NRC did not conduct any documented inspection activity of essential service water piping in any of the eight valve vaults even though on a yearly basis licensee personnel, in accordance with their procedures, opened on average five valve vaults to conduct inspections.

- This OIG inquiry disclosed that the NRC resident inspectors at Byron provided no regulatory review of operability evaluations completed at Byron in 2007 to support the licensee's lowering of the acceptable minimum wall thickness of essential service water system piping. Between July 11 and October 17, 2007,

EXELON staff completed three operability evaluations of essential service water system pipe risers in the valve vaults to support repeated lowering of the minimum acceptable wall thickness of these pipes from 0.153 inch to 0.03 inch. EXELON performed these operability evaluations because inspections of valve vaults on June 14, October 10, and October 17, 2007, resulted in measured pipe wall thicknesses that were, because of corrosion, repetitively less than the newly established minimum thicknesses. On June 14, the licensee measured a pipe wall thickness of 0.1222 inch in the E valve vault. This was less than the existing acceptable minimum thickness of 0.153 inch. On July 11, after performing a detailed operability evaluation, the licensee established a new minimum pipe wall thickness of 0.121 inch. On October 10, the licensee measured a pipe wall thickness in the H valve vault of 0.085 inch. On October 12, after performing a detailed operability evaluation, the licensee established a new acceptable minimum pipe wall thickness of 0.06 inch. On October 17, the licensee measured a pipe wall thickness in B valve vault of 0.047 inch. On October 17, 2007, after conducting a detailed operability evaluation, the licensee established a new minimum acceptable pipe wall thickness of 0.03 inch. The NRC resident inspectors at Byron during 2007 were aware that EXELON had conducted examinations of essential service water pipe risers in the valve vaults and had performed three operability evaluations that justified repeated reductions of the allowable pipe riser wall thickness. However, when the Byron resident inspectors, in accordance with an NRC inspection procedure, reviewed 21 operability decisions completed by EXELON in 2007, they reviewed none of the these three EXELON operability evaluations for technical sufficiency and adequate justification for operability.

- OIG found that while NRC inspection guidance required NRC inspectors to review a number of licensee operability evaluations conducted during a 1 year period, the guidance did not contain a methodology for NRC inspectors to follow when selecting review samples from a population that contained both detailed operability evaluations and simpler operability determinations. Additionally, NRC inspection guidance provided no direction to resident inspectors regarding NRC management expectations when the inspectors were confronted with a situation when a licensee had conducted a number of operability evaluations that repetitively reduced the margin of safety in plant equipment. Consequently, while in compliance with existing NRC inspection guidance, the Byron resident inspectors did not review any of the three safety significant operability evaluations conducted at Byron between July and October 2007 that justified an eventual 80% reduction in the acceptable minimum wall thickness of essential service water system riser piping.

- OIG determined that the NRC did not take full advantage of lessons learned from a 2004 event involving an essential service water system pipe rupture at the Vandellos nuclear plant in Spain. One of the contributing factors to the event was, similar to Byron, the location of the failure not subject to routine inspection because it was located in an infrequently accessed area. In October 2006, the World Association of Nuclear Operators (WANO) published a Significant Event Report describing the Vandellos event. The report was provided to the NRC by the Institute of Nuclear Power Operations. The WANO report provided 14 recommendations to address the various weaknesses that contributed to Vandellos event. In October 2006, after reviewing the WANO report, NRC

headquarters staff prepared an internal memorandum that acknowledged similarities between the Vandellos situation and essential service water systems in nuclear power plants in the United States. This internal memorandum included four recommendations to be implemented by NRC staff. While the NRC staff implemented, to varying degrees, three of the four recommendations, none of the operating experience or other guidance gained as a result the Vandellos incident, some of which was directly applicable to Byron, was communicated to the NRC resident inspectors on site at Byron.

FOOTNOTES:

1 The NRC initiated a Special Inspection Team (SIT) in October 2007 which consisted of Region III inspectors and a Region III Senior Reactor Analyst, with technical support from the Office of Nuclear Reactor Regulation Staff. The SIT was chartered to evaluate the facts, circumstances, and licensee actions surrounding the failure of the piping in the essential service water system at Byron.

2 EXELON Generation Company, LLC holds the NRC operating license for Byron

3 The two letter designation for the essential service water system at Byron is SX.

4 The cooling tower is shared for both reactor units

5 Some of the water is transported away from the system during evaporative cooling in the cooling tower. The basin receives additional water to make up for these evaporative losses.

6 The actual average is 5.57 days (39 days / 7 years) but reported here as a whole value

7 NRC INTEGRATED INSPECTION REPORT 50-454/02-07, January 29, 2003 (Resident Inspectors Routine Report) and NRC BIENNEL SAFETY SYSTEM DESIGN AND PERFORMANCE CAPABILITY BASELINE INSPECTION REPORT 05000454/2005002(DRS);05000455/2005002(DRS) May 20, 2005

8 NRC Inspection Procedure “Component Design Basis Inspection” IP 71111.21 was used in the performance of this Inspection

9 Generic Letter 91-18 Rev. 0 had two attachments from the NRCs Inspection Manual: (1) RESOLUTION OF DEGRADED OR NONCONFORMING CONDITIONS ADVERSE TO QUALITY OR SAFETY and (2) OEPRABLE/OPERABILITY:ENSURING THE FUNCTIONAL CAPABILITY OF A SYSTEM OR COMPONENT

10 OPERABILITY DETERMINATIONS & FUNCTIONALITY ASSESSMENTS FOR RESOLUTION OF DEGRADED AND NONCONFORMING CONDITIONS ADVERSE TO QUALITY OR SAFETY (OD PROCESS)

11 Further discussion regarding Part 9900 will be based on the 2005 version of the operability guidance.

12 The eight pipe risers are located in the valve vaults as the A, B, C, D, E, F, G, and H vaults respectively and are referred to by EXELON and NRC by the respective alphabetic designator.

13 On September 12 and September 28 visual inspections were performed in two valve vaults, one each on each day. No leakage was identified.

14 Licensees such as EXELON are required by regulation 10 CFR ?? 55 to have reactor operators who are licensed by the Nuclear Regulatory Commission (NRC), operators who have NRC licenses are referred to as licensed operators.

15 IP 71111.15 Operability Evaluations, July 2006 version

16 Vandellos Nuclear Plant is located in Spain

17 The World Association of Nuclear Operators (WANO) was created following the Chernobyl accident in 1986. One of the purposes of WANO is the collection and dissemination of operating experience to “allow members to learn from each other’s experience”

18 “MATERIAL DEGRADATION AND RELATED MANAGERIAL ISSUES AT NUCLEAR POWER PLANTS” Copyright 2006, IAEA

19 ESW is the more common generic acronym for essential service water in the industry

20 IMPROVEMENTS TO THE UNITED STATES NUCLEAR REGULATORY COMMISSION’S OPERATING EXPERIENCE PROGRAM, Speech Commissioner Peter B. Lyons, May 29, 2007 Cologne Germany

21 Internal memorandum Jung to Lee; September 29, 2006; Closure Memorandum Issue for Resolution 2005-090 Essential Service Water Piping Issues

22 International Event: Circumferential Break of Essential Water (ESW) Pipe at Vandellos-2 While Operating at Rated Power, dated June 6, 2005

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